Agilent Technologies

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Federal Communications Commission
Washington, D.C. 20554

In the Matter of	
Commission Seeks Public Comment on Spectrum Policy Task Force Report	ET Docket No. 02-135

COMMENTS OF AGILENT TECHNOLOGIES, INC.

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Introduction

Agilent Technologies, Inc. ("Agilent") submits these comments on the Spectrum Policy Task Force Report.[1] Agilent (formerly part of Hewlett-Packard) is a leading supplier of semiconductors, test and measurement equipment, design software, and test services. Agilent's products and services are used in a wide variety of applications, including radio design, manufacturing testing, type certification, interoperability testing, network operation, and spectrum management. Agilent's products have been used in the development of almost every new radio format and service, including cellular, DTV, MMDS, LMDS, Wi-Fi, Public Safety, satellite, and military and aeronautical applications.

Much of the SPTF Report focuses on measurements—measurements of spectrum utilization, measurements of spectral efficiency, noise measurements, and interference measurements. As one of the world's leading suppliers of measurement equipment, the bulk of Agilent's comments also will focus on the subject of measurements.

Interference Management and the Interference Thermometer

Agilent agrees that interference management, when combined with clearly defined user rights and responsibilities, could result in greater spectrum utilization. However, a practical interference thermometer is likely to be much more complicated than a single-metric measurement of an elevated noise floor. Receiver performance is affected by more than just the level of an interfering signal. For example, it is claimed by some that 8-VSB DTV receivers are less susceptible to impulsive noise than COFDM receivers.[2] This difference could be explained by the data interleavers used

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[1] *See* Spectrum Policy Task Force Report, ET Docket No. 02-135 (Nov. 2002) ("SPTF Report" or "Report"); *see also* Commission Seeks Public Comment on Spectrum Policy Task Force Report, Public Notice, ET Docket No. 02-135, FCC 02-322 (rel. Nov. 25, 2002).

[2] *See* DTV Report on COFDM and 8-VSB Performance, Office of Engineering and Technology, OET Report No. 99-2 (Sept. 30, 1999).

in the 8-VSB system, the design of which may have been based on the measured characteristics of existing interfering signals.

Similarly, Wi-Fi devices can operate at 2.4 GHz in the presence of significant energy from microwave ovens. This is possible because the characteristics of microwave oven signals are well understood and, therefore, predictable. The time-frequency characteristics of microwave ovens can be easily discerned in Figure 1 below, which shows time along the vertical axis and frequency along the horizontal axis. Even to the untrained eye, it is easy to discover the pattern of a microwave oven's signal, and to observe the dark areas where the spectrum is unused for short periods in time.

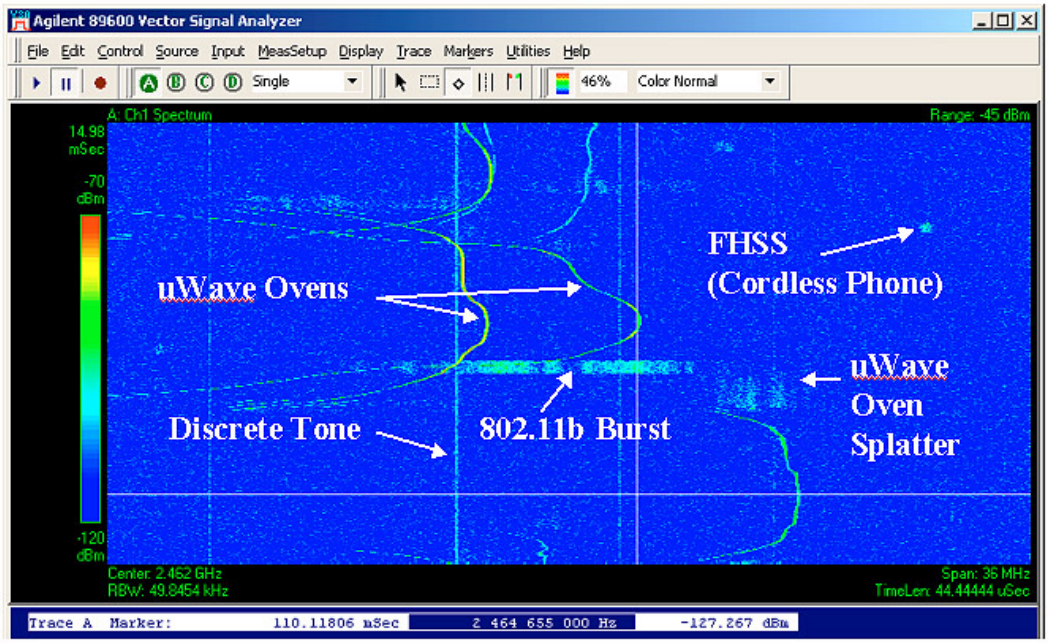

Figure 1: Spectrogram showing 36 MHz of spectrum for 15 milliseconds at 2.4 GHz

Wi-Fi and other devices designed for the 2.4 GHz ISM band prove that spectrum sharing can work. However, changes in the characteristics of interfering

signals can be devastating to low-cost devices such as Wi-Fi, as the assumptions upon which the devices were designed become invalid. For example, the introduction of RF Lighting at 2.4 GHz has caused some concern within the Wi-Fi industry.[3]

Software-defined radios ("SDR") may have an advantage in interference managed spectrum. New software can be downloaded into the radio to provide better PHY layer performance as new forms of interference are introduced and better techniques for measuring and mitigating interference are developed. In this regard, SDR may be the best "future proof" technology to use during the spectrum policy transition.

Agilent also makes the following observations:

- The accuracy of interference metrics, such as interference temperature, should be defined. Greater accuracy may result in more expensive receivers, but lack of accuracy may limit spectrum efficiency. Also, for FDD and/or smart antenna technology systems, the thermometer should be associated with the transmit signal (frequency, direction), not with the receiver. Multipath and flat fading may inherently limit the accuracy of interference thermometers, especially if the interference thermometer does not employ diversity antennas.

- Grouping technologies may be essential for practical interference management. The impact of a broadband signal on a narrowband receiver is different from the impact of a narrowband signal on a broadband receiver. A UWB signal that does not interfere with a narrowband receiver still may cause harmful interference to another UWB device should they share similar pulse rates.

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[3] *See In re Amendment of Part 18 of the Commission's Rules to Update Regulations for RF Lighting Devices*, ET Docket No. 98-42, Ex Parte Comments of Standars Working Group IEEE 802 (July 26, 1999).

OFDM signals have a periodic splatter associated with the symbol transitions, as shown in the upper plot of Figure 2 below. (A more traditional spectrum measurement is shown in the lower plot of Figure 2.) In the lower plot, the splatter at the left edge of the spectrum appears lower as the power is averaged over time—obscuring the impulsive characteristics that may result in harmful interference to other receivers.

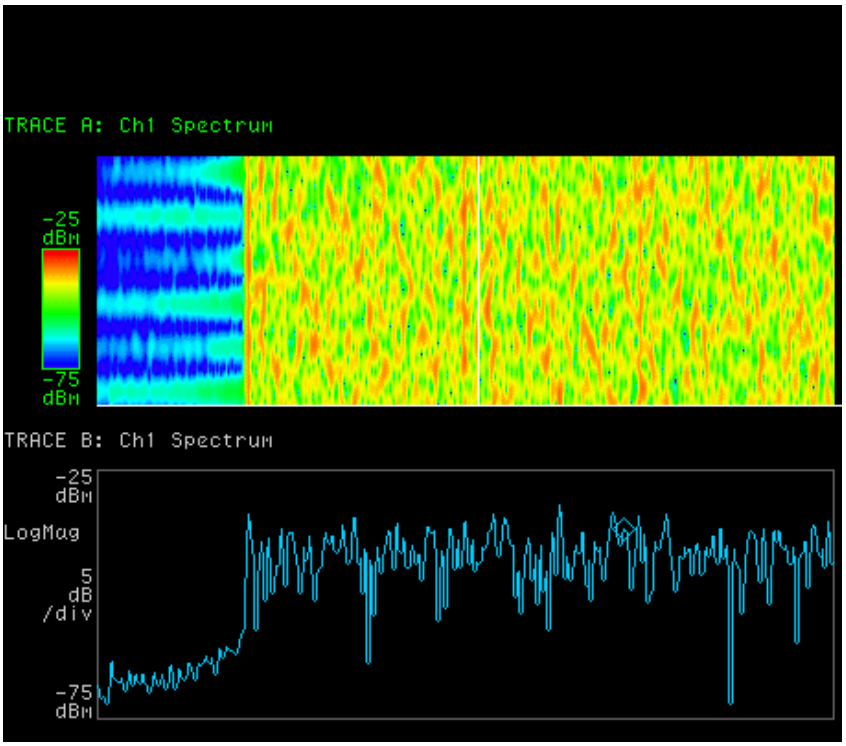

Figure 2: Periodic Spectral Splatter of an OFDM signal

- Smart antenna technology can increase spectral efficiency by concentrating energy where it can do the most good, and in some cases, directing energy away from where it can create interference (*e.g.*, null steering). The interference thermometer concept may prove to be incompatible with some smart-antenna technologies because the radiation pattern cannot be predicted at all points in space in a multipath environment. Interference management techniques and

policies should not inadvertently limit the deployment of other promising technologies that also increase spectral efficiency.

- It is not clear how an interference thermometer, especially one that is co-located with the transmitter, can overcome problems such as shadowing and the classical near-far problem. For example, consider a distant transmitter using the minimum amount of power necessary to communicate to a receiver in close proximity to a second radio that was measuring the interference temperature as a prelude to transmission. The second radio would determine that the interference temperature was low and begin to transmit, thereby blocking the reception of the nearby first receiver. If the first receiver is passive, or in a receive-only mode (*e.g.*, a broadcast receiver or pager), the second radio would continue to interfere, never being aware of the first receiver's existence.

Enforcement

Agilent agrees that spectrum policy reform and technology advances can result in greater spectrum utilization. The Commission, however, must give careful consideration to enforcement issues that are likely to accompany greater utilization and advanced radio technologies. The "tragedy of the commons" seems more likely if enforcement fails to track spectrum utilization. Agilent believes that the same advancements in technology that provide for greater spectrum utilization have the potential to increase monitoring and enforcement efficiency. Agilent also believes that advanced enforcement technology will be required to locate and document infractions of more advanced, intermittent, and agile transmitters, such as those that might be part of a software-defined radio.

Agilent further notes that it would be an extremely valuable exercise to engage in more extensive and detailed monitoring of existing spectrum usage practices. Such monitoring could be undertaken well in advance of any regulatory changes and

would ideally be carried out in a wide variety of settings. It could serve both to document the details of present activities as well as providing a learning process for the development of more refined monitoring instruments and methods. This, in turn, would enable the design of more efficient and expedient enforcement techniques.

Conclusion

Agilent suggests that any noise floor study, as recommend in the report, encompass more than a simple measurement of noise spectral density. The study should include statistical measures of observed signals (*e.g.*, signal bandwidth), burst length, time of occurrence, and frequency of occurrence. This information is necessary to document current usage, create usable interference metrics, and also could be used to specify receiver performance, which is a necessary step in creating useful measures of harmful interference.

Agilent agrees that the interference thermometer concept should be tested on a limited basis. There are many technical issues that need to be resolved. The success of the concept should be based on several different measures of efficiency. The concept may work well by some measures and fail by others. This will help determine where full deployment is warranted.

Finally, a successful commons model depends on enforcement of spectrum rights. If changes in spectrum policy are successful, and spectrum utilization increases, then so too will the task of enforcement. New technology needs to be developed in order to enable more efficient enforcement that makes a constructive, rather than obstructive, contribution to spectrum utilization.

Respectfully submitted,

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